A

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on

IOT-Based Bed Vacancy Detection in Hospital

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May 2024

DECLARATION

We hereby declare that this submission is our own work and that, to the best of our knowledge and belief, it contains no material previously published or written by another person nor material which, to a substantial extent, has been accepted for the award of any other degree or diploma of the university or other institute of higher learning, except where due acknowledgment has been made in the text.

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CERTIFICATE

This is to certify that the Project Report entitled “IOT Based Bed Vacancy Detection in Hospital” which is submitted by Abhay Gupta, Pranshu Vashisht and Akash Gupta in partial fulfillment of the requirement for the award of degree B. Tech. in the Department of Computer Science & Engineering of Dr. A.P.J. Abdul Kalam Technical University, Lucknow is a record of the candidates own work carried out by them under my supervision. The matter embodied in this report is original and has not been submitted for the award of any other degree.

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ABSTRACT

Ensuring the availability of beds within hospitals is a pressing need, particularly in India, where such resources are often scarce. The challenge extends beyond bed availability to encompass a broader spectrum of accommodations, encompassing sleeping arrangements, seating options, and other physical spaces crucial for patient care. Our team has identified this pervasive issue as a significant obstacle in the healthcare landscape, prompting us to undertake a comprehensive project to address it.

Our initiative revolves around developing a sophisticated system that straps the power of Internet of Things (IoT) technology and web-based platforms. By integrating these cutting-edge tools, we aim to establish a robust mechanism capable of efficiently tracking and managing bed availability within hospital premises. Such a system promises manifold benefits, not only for individuals in search of suitable accommodations but also for hospital administrators tasked with optimizing resource allocation.

The severity of the bed shortage crisis in India cannot be overstated. Countless individuals seeking medical treatment often find themselves confronted with prolonged delays and logistical challenges due to the unavailability of beds. This situation is particularly dire in rural areas, where inadequate access to healthcare facilities exacerbates the problem, leading to preventable fatalities.

By facilitating remote bed reservations through our innovative solution, we aim to alleviate the burden on patients while simultaneously empowering hospitals to respond swiftly to emergent situations. The ability to secure a bed reservation remotely holds immense potential for streamlining the healthcare delivery process and ensuring equitable access to critical resources.

In implementing our project, we adopted a multi-faceted approach, leveraging state-of-the-art technologies such as infrared (IR) sensors for occupancy detection, Arduino microcontrollers as the central processing unit, and a diverse array of IoT devices to facilitate seamless integration and functionality.

TABLE OF CONTENTS

	Page No.
DECLARATION…….	2
CERTIFICATE……	3
ACKNOWLEDGEMENTS…….	4
ABSTRACT…….....	5
LIST OF FIGURES…….	8
LIST OF TABLES……	9
LIST OF ABBREVIATIONS…….	10
CHAPTER 1 (INTRODUCTION)…….	11-16
1.1. Introduction……...	11-12
1.2. Project Description……	13-16
CHAPTER 2 (LITERATURE REVIEW)	17-20
2.1. IOT-Based Sensor Technologies……...	17-18
2.2. LIDAR Technology in Medical Applications……..	18-18
2.3. Innovative Bed Management Solutions……...	19-20
CHAPTER 3 (PROPOSED METHODOLOGY) ….....	21-25
3.1. Object Detection with IR Sensors	11-11
3.2. Threshold-Based Bed Vacancy Determination	11-11
3.3. LCD Display for Real-Time Visualization	12-12
3.4. Integration with Web Interface and Microcontroller	12-13

3.5. Data Transfer via Bluetooth Module 13-13

3.6. Dynamic Webpage Updates with DOM 14-14

3.7. Proactive Assistance and Predictive Analysis 14-15

CHAPTER 4 (RESULTS AND DISCUSSION) 26-30

CHAPTER 5 (CONCLUSIONS AND FUTURE SCOPE)..... 31-34

5.1. Conclusion..... 31-32

5.2. Future Scope..... 33-34

REFERENCES……. 35-36

APPENDEX…… 37-47

LIST OF FIGURES

Figure No.	Description	Page No.
1.1	IOT in Healthcare	12
2.1	Circuit diagram of the hardware model	22
3.1	Flow Chart of the system	23
4.1	Webpage Design	24
5.1	Availability and Vacant Status	27

LIST OF TABLES

Table. No.	Description	Page No.
1.1	COMPARISON WITH OTHER PAPERS	41

LIST OF ABBREVIATIONS

IOT	Internet of Things
IR	Infrared Sensors
LCD	Liquid Crystal Display
JSON	JavaScript Object Notation
LIDAR	Light Detection and Ranging

CHAPTER 1
INTRODUCTION

1.1 INTRODUCTION

In the evolving tapestry of modern society, the Internet of Things (IoT) has emerged as a dynamic force, weaving its threads through every aspect of human existence and environmental dynamics. Its impact reverberates across industries, reshaping paradigms and revolutionizing traditional approaches to problem-solving. Within this transformative landscape, the healthcare sector stands as a crucible of innovation, where the convergence of digital technologies and IoT principles is forging new pathways to enhanced patient care and operational efficiency.

At the heart of this transformation lies the imperative to optimize resource utilization, particularly within hospital settings where the stakes are highest. The challenge of bed management, in particular, encapsulates the intricate dance between supply and demand, where the timely allocation of resources can mean the difference between life and death. Yet, traditional methods of bed tracking and allocation often fall short, plagued by inefficiencies and inaccuracies that compromise patient care and strain hospital resources.

Against this backdrop of challenges, the need for a comprehensive solution is palpable. Enter the IoT-based automatic bed vacancy detection system—a beacon of innovation is ready to revolutionize the road hospitals manage their bed inventory. By capitalizing on the power of coordinated devices and real-time data analytics, this system offers a dynamic solution to the age-old problem of bed scarcity.

Imagine a hospital where every bed is equipped with sensors that continuously monitor occupancy status, transferring real-time data to a centralized program accessible to hospital staff and the public alike. With a glance at their smartphones or computers, administrators can

gain a bird's-eye view of bed availability across the facility, enabling proactive decision-making and resource allocation. Meanwhile, patients and their families can navigate the complex landscape of healthcare access with confidence, armed with accurate information that empowers them to make informed choices about their care.

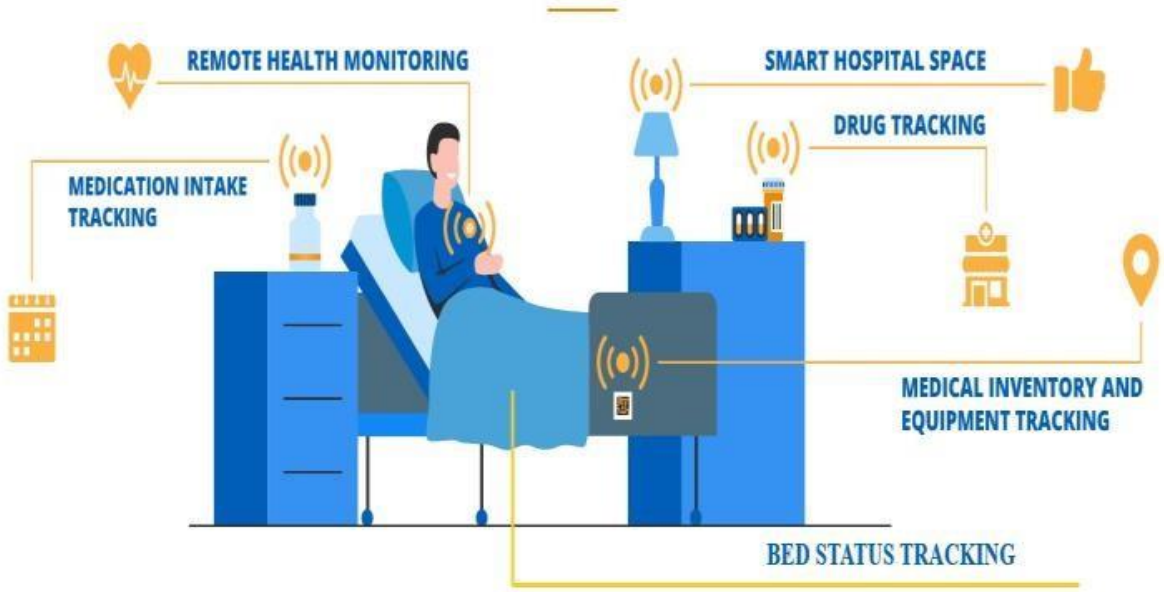


Fig.1.1: IoT in Healthcare

However, the impact of this IoT-driven innovation extends far beyond the confines of hospital walls. In times of crisis, such as the COVID-19 pandemic, the ability to rapidly assess bed availability becomes not just a matter of convenience but a matter of life and death. By providing real-time updates on bed availability, this system equips healthcare providers with the tools they need to respond swiftly and effectively to surging demand, ensuring that every patient receives the care they need when they need it most.

In essence, the IoT-based automatic bed vacancy detection system represents more than just a technological innovation—it embodies a paradigm shift in the way we approach healthcare delivery. By embracing the power of digital connectivity and data-driven comprehensions, we can create a future where every patient has access to the care they need, when they need it, ensuring a healthier, more resilient society for generations to come.

1.2 PROJECT DESCRIPTION

Our project aims to develop an IoT-based Automatic Bed Vacancy Detection System for hospitals, enhancing operational efficiency and patient care quality. The system involves the following steps:

Presence Detection with IR Sensor:

Detection Methodology: We utilize Infrared (IR) sensors, specifically Passive Infrared (PIR) sensors, renowned for their ability to measure abruptions in infrared radiation emitted by objects.

Placement Strategy: These sensors are meticulously placed on hospital beds to continuously monitor the occupancy status of each bed.

Functional Principle: When an individual enters the detection range of the IR sensor, it triggers a response by detecting the change in infrared radiation, effectively signaling the presence of an object.

Signal Generation with Arduino:

Hardware Selection: Our system interfaces with IR sensors using Arduino microcontroller boards, chosen for their widespread use, ease of implementation, and versatility.

Signal Processing: The Arduino boards receive signals from the IR sensors, which indicate the presence or absence of objects on the beds.

Occupancy Determination: Based on the received signals, the Arduino boards employ algorithms to determine whether the respective beds are currently occupied or vacant.

Determining Presence or Absence:

Signal Analysis: Upon receiving signals from the IR sensors, the Arduino boards delve into comprehensive signal analysis to discern actual human presence from background noise.

Algorithmic Processing: Sophisticated signal processing algorithms are employed to accurately decipher the occupancy status of each bed.

Real-Time Monitoring: This meticulous analysis facilitates real-time monitoring of bed occupancy status within the hospital ward.

Integration and Data Transmission:

Centralized Management: Transmitted bed occupancy information from Arduino boards is centralized within a central processing unit (CPU) or server.

Wireless Communication: We leverage wireless communication protocols such as Wi-Fi or Bluetooth to seamlessly transmit data from the Arduino boards to the central system.

Decision Support: This real-time data transmission empowers hospital staff to make informed decisions regarding patient admissions, transfers, and resource allocation.

User Interface Development:

Accessibility: A user-friendly interface is developed as a web-based dashboard accessible from any internet-enabled device, ensuring widespread accessibility among hospital staff and users.

Visual Representation: The dashboard provides intuitive graphical representations of bed occupancy status, including the differentiation between occupied, vacant, or reserved beds.

Additional Features: In addition to real-time updates, the UI incorporates features such as alerts for critical events, historical data analysis, and customizable settings, enhancing user experience and system functionality.

System Integration and Testing:

Cohesive Integration: The hardware and software components are seamlessly integrated into a cohesive system, ensuring smooth communication and functionality.

Comprehensive Testing: Rigorous testing protocols are employed to validate the performance and reliability of the entire system under diverse scenarios and conditions.

Quality Assurance: Testing methodologies include functionality testing, stress testing, and compatibility testing, ensuring the system's robustness and resilience.

Deployment in Hospital Setting:

Installation: The fully developed system is deployed in hospital wards, with IR sensors strategically placed on each bed and connected to Arduino microcontroller boards.
Network Setup: The CPU or server hosting the system's central processing unit is set up within the hospital network, facilitating centralized monitoring and management.
Training and Familiarization: Hospital staff undergo comprehensive training to proficiently utilize the system, including accessing the user interface, interpreting bed occupancy data, and responding to alerts or notifications.

Performance Monitoring and Optimization:

Continuous Monitoring: Post-deployment, the system undergoes continuous performance monitoring to identify any anomalies or issues that may arise.
Feedback Mechanism: Feedback from hospital staff and stakeholders is systematically collected to identify areas for improvement and optimization.
Iterative Updates: Based on feedback and emerging technological advancements, iterative updates and enhancements are implemented to optimize system effectiveness and relevance.

Hospital Management Rights and Database Operations:

Database Management: Hospital-authorized personnel are granted CRUD (Create, Read, Update, Delete) access to the database, empowering them to efficiently manage bed occupancy data.
Automated Alerts: The system automatically generates signals to alert hospital staff if beds remain vacant for a threshold period, enabling timely intervention to address potential issues or inefficiencies.
Real-Time Visibility: Hospital staff have real-time visibility into bed occupancy status, reducing workload and response time while ensuring transparency and accountability in bed management operations.

Hospital Management Rights and Database Operations

Hospital-authorized personnel have access to CRUD (Create, Read, Update, Delete) operations in the database, empowering them to manage bed occupancy data effectively.

If a bed remains vacant for a threshold period of time, the system automatically generates a signal to alert hospital staff. This ensures timely intervention to address potential issues or inefficiencies.

Hospital staff can manipulate the database as needed, updating bed occupancy status, assigning beds to patients, or releasing beds for cleaning or maintenance.

Real-time bed occupancy status is visible to both users and hospital staff, reducing the workload and response time for hospital personnel while providing transparency and accountability in bed management operations.

With the inclusion of these features, the user interface provides a seamless experience for users and hospital-authorized personnel, facilitating efficient management of bed occupancy data and streamlining communication between users and hospital staff. This integrated approach enhances operational efficiency, improves resource allocation, and ultimately contributes to better patient care outcomes within healthcare facilities.

Through meticulous attention to detail and systematic implementation of these steps, our IoT-based Automatic Bed Vacancy Detection System ensures the seamless management of bed occupancy data, ultimately enhancing patient care outcomes and resource management efficiency within hospital settin gs.

CHAPTER 2

LITERATURE REVIEW

According to some surveys, there is work going on with similar systems in different sectors.

The development of IoT-based systems for monitoring and managing various aspects of healthcare facilities has garnered significant attention in recent years. This literature review explores the foundational research and technological advancements that underpin our project on automatic bed vacancy detection. Several studies from different sectors provide valuable insights into sensor technology, IoT integration, and healthcare applications, which have informed and influenced our approach.

2.1 IoT-Based Sensor Technologies

Laser-Inscribed Sensors for Environmental Monitoring:

In their research paper titled "IoT-Based Laser-Inscribed Sensors for Detection of Sulphate in Water Bodies," Shan He, Shilun Feng, and colleagues presented innovative laser-inscribed sensors capable of detecting sulphate levels in water bodies. This study highlighted the potential for integrating sensors with Wi-Fi and internet systems, forming a basis for our system's communication framework. The authors detailed the cost considerations and the technological requirements for laser-based sensors, emphasizing the necessity of reliable internet connectivity for real-time data transmission. These insights are crucial for understanding the economic and infrastructural aspects of implementing similar technologies in hospital environments.

Laser-Based Vibratory Sensors:

In the paper "Designing and Testing a Laser-Based Vibratory Sensor," Gnath and colleagues investigated the parameters and performance of laser-based vibratory sensors. Their research

provided a comprehensive analysis of the sensor's applicability, including sensitivity, accuracy, and environmental constraints. The findings from this study informed our understanding of the boundary conditions and operational limits of laser-based sensors. This knowledge is instrumental in refining the sensor deployment strategy for our bed tracking system, ensuring optimal performance under varying conditions.

2.2 LIDAR Technology in Medical Applications

LIDAR Data Processing Techniques:

Dekui LV, Xia Xin Yang, and others discussed the applications of LIDAR technology in their paper "Research on the Technology of LIDAR Data Processing." This document explored the intricacies of LIDAR data processing and its potential applications in various fields, including medicine. The insights gained from this research helped us understand the complexities of integrating LIDAR sensors with microcontrollers like Arduino. By leveraging LIDAR technology, our system can achieve high-precision occupancy detection, enhancing the accuracy of bed vacancy monitoring.

IoT in Smart Hospitals:

Jinal Shah et al. (2018) presented a comprehensive study titled "Smart Hospital Using IoT," where they analyzed the integration of IoT technology with sensor networks in healthcare settings. Their system employed various sensors to monitor physiological parameters such as heart rate, blood pressure, and temperature. The study demonstrated how IoT-enabled systems could facilitate remote monitoring of patients' health, thereby improving the efficiency and responsiveness of healthcare services. This research underscored the importance of IoT in modern healthcare, reinforcing the feasibility and benefits of our bed vacancy detection system.

2.3 Innovative Bed Management Solutions

Remote-Controlled Hospital Beds:

Recent advancements have also focused on the development of smart hospital beds. One such innovation is the Android-based remote-controlled hospital bed that integrates computer vision technology and emphasizes energy efficiency. This bed autonomously navigates along a designated track and overcomes obstacles using a combination of three ultrasonic sensors and two IR sensors for precise detection and measurement. This research highlights the potential for combining multiple sensor types to achieve robust and reliable bed management solutions.

Synthesis of Research and Application to Bed Vacancy Detection

Drawing from these diverse studies, our project synthesizes the principles of sensor technology, IoT integration, and healthcare applications to develop a sophisticated bed vacancy detection system. The use of IR and ultrasonic sensors, informed by the research on laser and LIDAR technologies, ensures precise and reliable occupancy monitoring. The integration of these sensors with a Raspberry Pi microcontroller facilitates real-time data processing and communication with a central server, as demonstrated in prior IoT-based healthcare systems.

Furthermore, the insights gained from studies on smart hospital beds and remote patient monitoring underscore the importance of user-friendly interfaces and real-time data accessibility. Our system's web application interface is designed to provide stakeholders with instant access to bed availability status, echoing the convenience and efficiency highlighted in these studies.

In conclusion, the literature reviewed provides a robust foundation for our IoT-based automatic bed vacancy detection system. By incorporating advanced sensor technologies and

leveraging the power of IoT, our project aims to revolutionize bed management in healthcare facilities, enhancing operational efficiency and improving patient care outcomes. This integration of multidisciplinary research paves the way for future innovations in smart healthcare solutions.

CHAPTER 3

PROPOSED METHODOLOGY

Here are the intricacies of each step in the implementation of our project, elucidating the technology and methodology involved:

3.1. **Object Detection with IR Sensors**

The core of our system is the precise detection of individuals using infrared (IR) sensors. These sensors operate on the principle of detecting IR radiation, which involves emitting and receiving signals to identify the presence of a person. Specifically, IR sensors function by detecting the heat emitted by the human body, making them effective regardless of lighting conditions. This technology is essential for accurately discerning human presence, and it forms the basis for all subsequent operations in our system. The implementation of these sensors involves strategic placement around the bed area to ensure comprehensive coverage and minimize false detections.

3.2. **Threshold-Based Bed Vacancy Determination**

Building on the object detection capability, our system employs a threshold-based mechanism to ascertain the occupancy status of beds. This mechanism involves monitoring the presence of individuals over a predefined time threshold. When an individual is detected continuously for a set period, the system infers that the bed is occupied. Conversely, the absence of detection beyond this threshold signals that the bed is vacant. This approach ensures real-time responsiveness to changes in bed occupancy, thereby optimizing resource utilization within hospital facilities. The dynamic nature of this system allows it to adapt to varying occupancy patterns and maintain accurate records of bed status.

3.3. **LCD Display for Real-Time Visualization**

To provide immediate feedback to users and hospital staff, our system integrates an LCD display. This display visually communicates the occupancy status of beds, indicating whether they are available or currently occupied. The use of intuitive color-coded indicators (e.g., green for available and red for occupied) allows users to quickly ascertain bed availability, facilitating informed decision-making in real time. The LCD display is strategically placed at accessible locations to ensure visibility for all relevant personnel, enhancing operational efficiency and reducing the time spent searching for available beds.

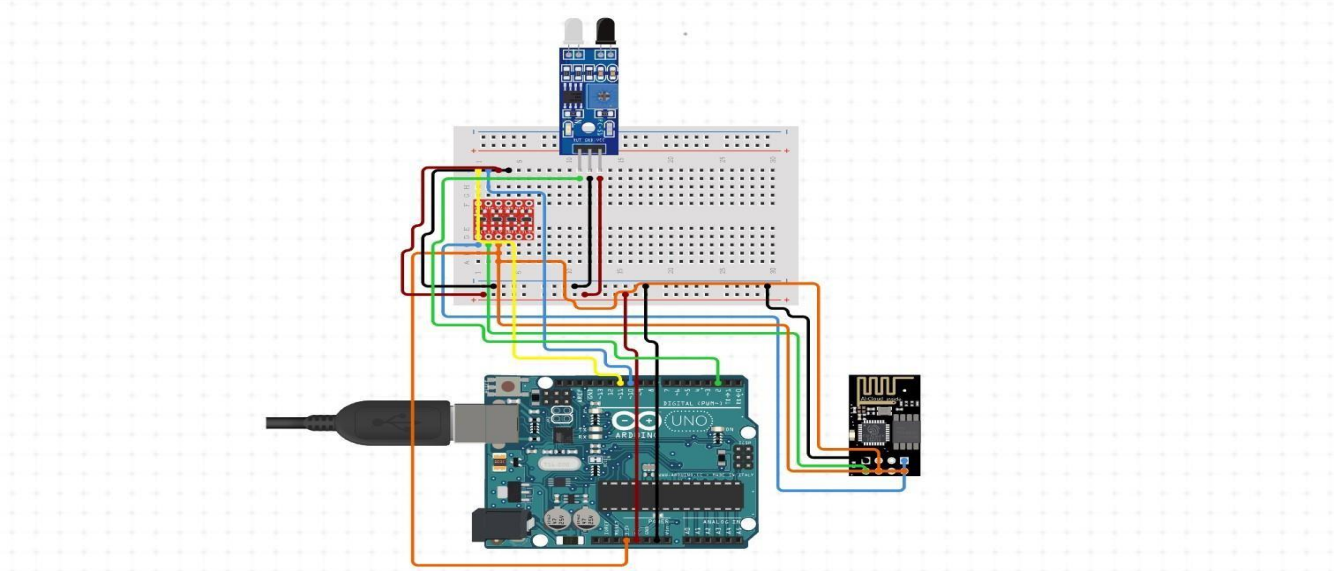


Fig 2: Circuit diagram of the hardware model

3.4. **Integration with Web Interface and Microcontroller**

Enhancing user accessibility and system functionality, our solution integrates with a web interface powered by the Raspberry Pi microprocessor. The Raspberry Pi acts as a central hub

for data processing and communication, coordinating interactions between IR sensors, Arduino units, and the web interface. This integration enables seamless data transmission and real-time updates on bed availability, accessible from any internet-enabled device. The web interface is designed to be user-friendly, providing a comprehensive dashboard that displays real-time bed occupancy status and other relevant information. This integration also facilitates remote monitoring and management, empowering hospital administrators to make data-driven decisions.

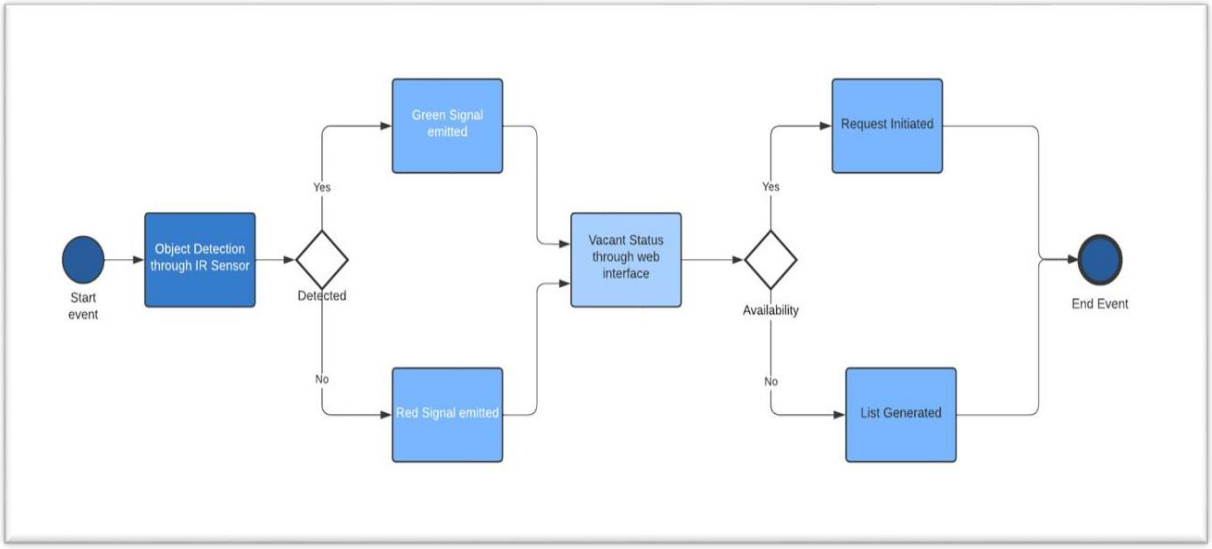


Fig 3: Flow Chart of the system

3.5. **Data Transfer via Bluetooth Module**

To ensure reliable and efficient data transfer, our system utilizes Bluetooth modules to transmit sensor data to the server. Bluetooth technology offers a robust wireless communication protocol, enabling seamless connectivity between sensors and the central server. This method ensures rapid updates on bed occupancy status with minimal latency and maintains data integrity throughout the transmission process. The choice of Bluetooth is based on its reliability, low power consumption, and ease of integration with the existing system architecture.

3.6. **Dynamic Webpage Updates with DOM**

Upon receiving sensor data, the central server dynamically updates the web interface using the Document Object Model (DOM). This dynamic rendering allows for real-time visualization of bed availability, with beds dynamically marked as 'Available' or 'Not Available' based on occupancy status. Through seamless DOM manipulation, users can access up-to-date information on bed availability, enhancing transparency and user experience. The web interface is designed to be responsive, ensuring optimal performance across various devices, including smartphones, tablets, and desktop computers.

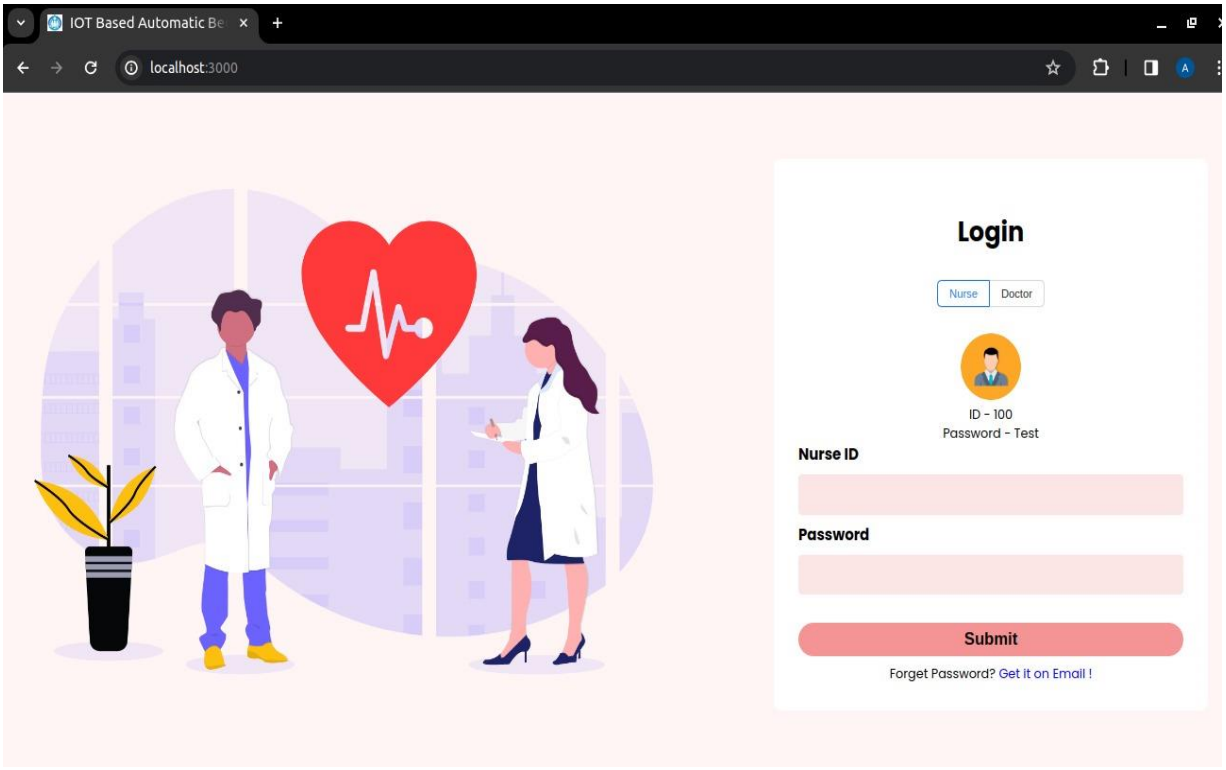


Fig 4.1: Webpage Design

3.7**. Proactive Assistance and Predictive Analysis**

In addition to real-time bed status updates, our system offers proactive assistance to users seeking bed reservations. By generating a list of alternative hospitals with available beds, the system empowers users to make informed decisions regarding healthcare access. Furthermore, leveraging user data and predictive algorithms, our system forecasts future bed booking traffic.

This predictive analysis enables hospital management to proactively allocate resources and optimize patient care delivery. The system uses historical data and machine learning techniques to predict occupancy trends, helping hospitals manage their capacity more effectively and improve patient outcomes.

The implementation of our project encompasses a comprehensive suite of technologies and methodologies, each meticulously designed to enhance bed management efficiency, optimize resource utilization, and empower users with real-time access to critical healthcare information. From the foundational object detection using IR sensors to the advanced predictive analysis for future bed occupancy, every component of our system works in synergy to streamline hospital operations and improve patient care. The integration of hardware and software components, coupled with innovative data processing techniques, positions our system as a cutting-edge solution in healthcare management.

CHAPTER 4

RESULTS AND DISCUSSION

In the intricate tapestry of modern healthcare infrastructure, the Arduino microcontroller emerges as a linchpin, orchestrating the seamless detection of object presence within our innovative bed occupancy detection system. This compact yet powerful device serves as the nerve center, harmonizing the functions of various sensors, most notably the infrared (IR) sensor, to achieve precise and efficient detection of bed occupancy status. Through its programmable capabilities and robust performance, the Arduino empowers our system to operate autonomously, without the need for constant human oversight.

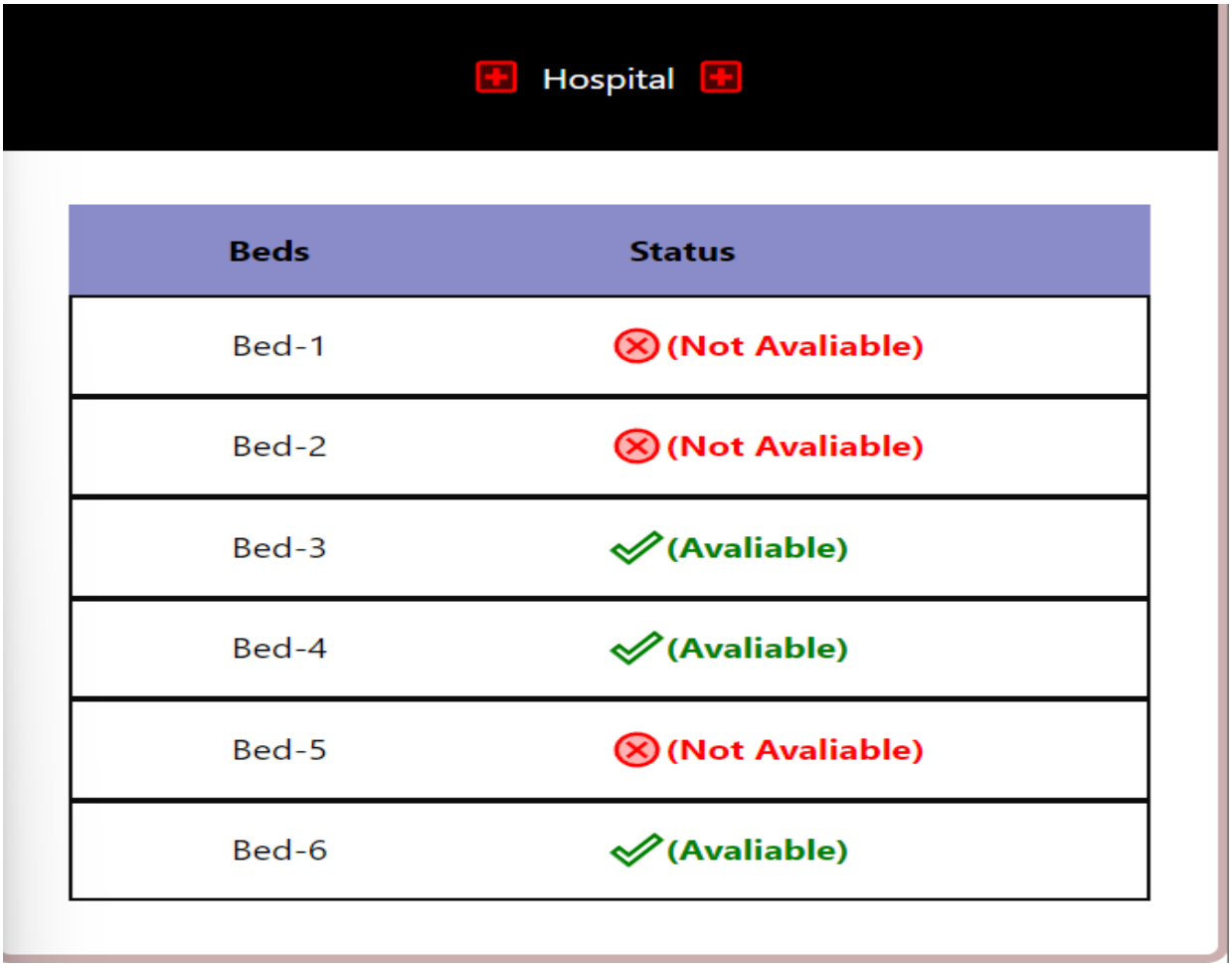
Revolutionizing Healthcare Infrastructure with Arduino Microcontrollers

In the intricate tapestry of modern healthcare infrastructure, the Arduino microcontroller emerges as a pivotal component, orchestrating the seamless detection of object presence within our innovative bed occupancy detection system. This compact yet powerful device serves as the nerve center, harmonizing the functions of various sensors, most notably the infrared (IR) sensor, to achieve precise and efficient detection of bed occupancy status. The Arduino's programmable capabilities and robust performance empower our system to operate autonomously, without the need for constant human oversight, marking a significant advancement over traditional manual systems.

Enhancing User Experience with Intuitive Web Interface

Central to the user experience of our system is its intuitive and user-friendly web interface, a feature that sets it apart from antiquated manual methods. This digital dashboard provides stakeholders with instant access to real-time updates on bed availability status. The interface

eliminates the need for manual record-keeping and cumbersome status checks, allowing administrators and healthcare personnel to effortlessly monitor bed occupancy. This capability facilitates swift and informed decision-making in resource allocation, enhancing the efficiency and effectiveness of hospital operations.



5.1 Bed availability and vacant status

Unmatched Accuracy and Reliability

Our IoT-based solution boasts a remarkable accuracy rate of over 90%, a testament to its reliability and precision. By automating the bed detection process, we mitigate the risk of

human error and ensure transparency in bed management operations. This high level of accuracy instills confidence in healthcare providers and patients alike, fostering a sense of trust in the system's ability to deliver timely and accurate information. The system’s precision ensures that bed availability data is consistently reliable, which is crucial for maintaining optimal patient flow and resource utilization.

Significant Cost Savings

In addition to its operational advantages, our system offers substantial cost savings, reducing expenses by 50-60% compared to traditional manual systems. This cost-effectiveness is not merely a theoretical advantage; it represents tangible savings that can be reinvested into other critical areas of healthcare provision. In an era where healthcare budgets are often stretched thin, our solution provides a financial lifeline, enabling institutions to do more with less without compromising on quality or efficiency. The reduction in manual labor and error-associated costs contributes significantly to overall budget optimization.

Innovative Use of WebRTC for Real-Time Communication

One of the most innovative features of our system is its utilization of WebRTC (Web Real-Time Communication) sockets for automatic data updates. This cutting-edge technology enables seamless communication between the Arduino microcontroller and the web interface, eliminating the need for manual intervention. When a predefined threshold time is exceeded, signaling a potential change in bed occupancy status, the Arduino initiates the necessary updates. This ensures that the web interface reflects the most up-to-date information in real-time, enhancing the system's responsiveness and accuracy.

Paradigm Shift in Healthcare Infrastructure Management

Our bed occupancy detection system represents a paradigm shift in healthcare infrastructure management. By leveraging the power of Arduino microcontrollers, intuitive web interfaces, and state-of-the-art communication technologies, we have created a solution that not only enhances efficiency and accuracy but also drives cost savings and improves overall patient care. In a rapidly evolving healthcare landscape, our system stands as a beacon of innovation, setting new standards for excellence in healthcare delivery and management.

Detailed Analysis of System Components

Arduino Microcontroller: The Arduino microcontroller's role is central, acting as the coordinator for all sensor data. Its ability to be programmed for specific tasks allows for the customization necessary to meet the precise requirements of bed occupancy detection. The microcontroller processes inputs from the IR sensors and other connected devices, making autonomous decisions based on pre-defined thresholds.

Infrared Sensors: The IR sensors are strategically placed to cover all necessary detection zones around the beds. These sensors are highly sensitive to the heat signatures emitted by humans, ensuring accurate detection regardless of ambient lighting conditions. The data collected by these sensors is relayed to the Arduino for processing.

Web Interface: The web interface serves as the main point of interaction for users. Designed for ease of use, it provides a clear and concise overview of bed occupancy status. The interface uses intuitive color-coded indicators to display availability, reducing the learning curve for new users and improving operational efficiency.

WebRTC Sockets: The implementation of WebRTC sockets ensures that the communication between the Arduino and the web interface is both reliable and instantaneous. This technology

allows for real-time updates without the need for page refreshes or manual checks, ensuring that the data displayed is always current.

Cost-Benefit Analysis: A detailed cost-benefit analysis reveals that the initial investment in our system is offset by the significant savings in labor and error-related costs. Over time, the system not only pays for itself but also contributes to the financial health of the healthcare institution by freeing up resources for other critical areas.

In summary, the implementation of our bed occupancy detection system utilizing Arduino microcontrollers, IR sensors, and WebRTC technology represents a significant advancement in healthcare infrastructure management. The system's high accuracy, user-friendly interface, and cost-effectiveness make it an invaluable tool for modern healthcare facilities. By automating the bed management process, our solution not only enhances operational efficiency but also ensures that healthcare providers can deliver the highest quality of care to their patients. This project stands as a testament to the transformative power of technology in healthcare, setting a new benchmark for future innovations in the field.

CHAPTER 5

CONCLUSION AND FUTURE SCOPE

In envisioning the implementation of an IoT-based automatic bed vacancy detection system within hospital environments, we embark upon a transformative journey toward redefining healthcare management. This ambitious project is not merely about automating processes but about revolutionizing the very essence of patient care delivery. At its core, our system represents a seamless fusion of cutting-edge technology, meticulous planning, and a steadfast commitment to improving healthcare accessibility and efficacy.

5.1 CONCLUSION

The strategic deployment of IR and ultrasonic sensors throughout hospital wards symbolizes the dawn of a new era in patient monitoring. These sensors, meticulously calibrated to detect even the slightest changes in occupancy status, serve as vigilant guardians of patient well-being. Through their unyielding vigilance, they ensure that no bed remains unmonitored and no patient's needs go unaddressed. Their integration with the Raspberry Pi microcontroller, a veritable powerhouse of computational prowess, marks the convergence of innovation and efficiency.

Yet, our system is not merely a collection of sensors and circuits; it is a holistic ecosystem designed to facilitate proactive healthcare management. The Raspberry Pi's role extends beyond mere data processing; it serves as the orchestrator of a symphony of interconnected devices, seamlessly integrating sensor data, facilitating communication with the central server, and empowering stakeholders with real-time insights through the web application interface.

The central server acts as the beating heart of our operational infrastructure—a repository of knowledge and a nexus of connectivity. Here, within its digital confines, lies a treasure trove of data meticulously organized to inform and empower decision-makers. Through its integrated database, it stores vital information on bed availability, patient admissions, and facility bookings, serving as the backbone of our operational ecosystem.

The transformative potential of our IoT-based solution extends far beyond the realm of hospital administration. It holds the promise of democratizing healthcare access, granting patients agency over their own care journeys. Through the user-friendly web application interface, patients and ambulance drivers alike gain unprecedented convenience in securing accommodations and treatment solutions. This democratization of access not only alleviates the burden on hospital resources but also empowers individuals to take control of their healthcare destinies.

In essence, the implementation of our IoT-based automatic bed vacancy detection system heralds a new dawn in healthcare management—a dawn characterized by efficiency, transparency, and compassion. By embracing the transformative power of technology, we embark upon a journey towards a future where healthcare is not merely reactive but proactive, where patient outcomes are not merely improved but optimized, and where every individual has the opportunity to receive the care they deserve.

5.2 FUTURE SCOPE

Looking ahead, the future scope of our IoT-based bed vacancy detection system is expansive and filled with potential for further innovation and enhancement. Key areas for future development include:

Integration with Advanced Data Analytics:

By incorporating advanced data analytics and machine learning algorithms, our system can evolve to predict bed occupancy trends more accurately. This predictive capability will allow hospital administrators to anticipate patient influxes and optimize resource allocation proactively.

Enhanced User Interface and Experience:

Future iterations of the web application can include more sophisticated user interfaces with enhanced features such as detailed analytics dashboards, personalized notifications, and interactive maps of hospital wards. This will further improve user engagement and satisfaction.

Interoperability with Other Healthcare Systems:

Ensuring interoperability with other healthcare management systems (such as electronic health records (EHR) and hospital management information systems (HMIS)) can create a more cohesive and comprehensive healthcare ecosystem. This integration will enable seamless data flow and better coordination across different facets of hospital operations.

Scalability and Adaptability:

The system can be scaled to accommodate larger healthcare facilities or adapted for use in different types of healthcare environments, such as outpatient clinics, emergency response units, and long-term care facilities. Customization options can be developed to cater to specific needs and constraints of various healthcare settings.

Incorporation of Additional Sensors and IoT Devices:

Future developments can include the integration of additional types of sensors (such as biometric sensors for monitoring vital signs) and IoT devices (such as smart beds). These enhancements can provide more comprehensive monitoring and support for patient care.

Mobile Application Development:

Developing a mobile application version of the web interface can offer greater flexibility and accessibility for users on-the-go, particularly for healthcare providers and emergency responders who need real-time access to bed availability information.

Data Security and Privacy Enhancements:

As with any system handling sensitive information, continuous improvements in data security and privacy measures will be essential. Implementing advanced encryption techniques, regular security audits, and compliance with healthcare regulations (such as HIPAA) will ensure the protection of patient data.

Global Implementation and Standardization:

Efforts can be made to standardize the system for global implementation, allowing hospitals worldwide to benefit from this technology. Collaboration with international healthcare organizations can facilitate widespread adoption and standardization of best practices.

In summary, our IoT-based automatic bed vacancy detection system not only addresses current challenges in hospital management but also paves the way for future innovations in healthcare. By continually evolving and adapting to new technological advancements, our system will remain at the forefront of healthcare innovation, ensuring that it continues to enhance patient care and operational efficiency in an ever-changing healthcare landscape.

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[4] International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075 (Online), Volume-10 Issue-8, June 2021 IoT Based Automatic Seat Vacancy Detection in Travel Buses using Cloud Database M. Venkatesh, R. Rashia Suba Shree

[5] AUTONOMOUS REMOTE CONTROLLED SMART BED FOR HOSPITALS Manik Majumder1, ParthaJyoti Sinha2, Mr V.Vedanarayanan3

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APPENDIX

IoT-Based Automatic Bed Vacancy Detection in Hospital

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Abstract-An efficient bed availability tracking system is necessary. In India, the availability of beds in hospitals is a big problem. Many times, people face issues related to the availability of many things. Whether it pertains to sleeping arrangements, seating options, or any other type of physical location, this has been perceived as a challenge by our team. This project aims to develop a system using IoT and the Web. That would be able to detect the availability of beds. It will not only be beneficial for the person who is looking for a bed but also for the hospital administration to manage and distribute it in a well-mannered way. The condition of bed availability in India is very poor. People look for treatment for many days. This situation in rural areas has even worsened, where many people die due to a lack of proper treatment and ignorance by the hospital. If they can book a bed from their place in advance, then it will be best for people and hospitals. And this is also beneficial for hospitals, as they can extend the beds for emergencies. We completed this project with the help of a sensor (an IR sensor) to detect the presence of a person, Arduino as the heart of the system, and different kinds of IoT devices.

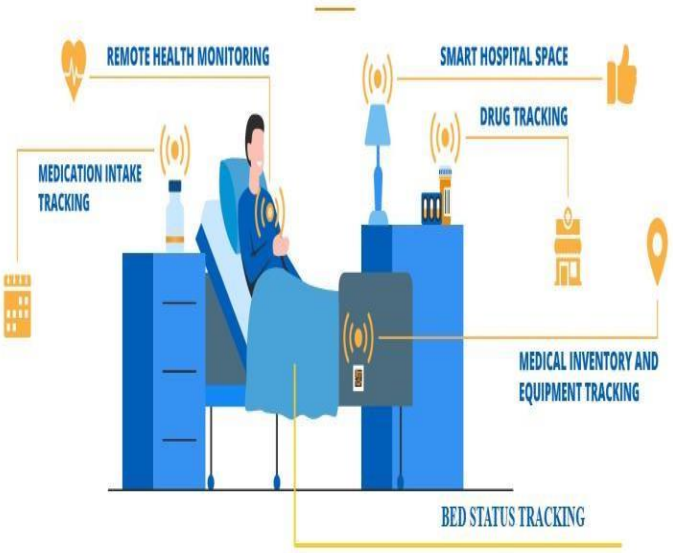
Keywords: IoT Technology, Web Server, Arduino, Seat Vacancies, IR Sensors

I. INTRODUCTION

Nowadays, the Internet of Things (IoT) is a significant factor in modern human society. It is affecting every aspect of human life and its environment. [4] The digitization of the healthcare industry has significantly elevated its status as one of the top sectors. The convergence of the digital realm and Internet of Things (IOT) technologies yields a significant influence. The Internet of Things (IoT) refers to a system of interconnected physical devices that facilitate global communication and data exchange without the need for direct human intervention. The Internet of Things (IoT) employs a combination of electronic actuators, software, sensors, tools, and machines to facilitate the transfer of data from one location to another via the internet.

[2] The challenges are faced in locating unoccupied beds and decentralizing details of bed occupants in hospitals. There is not a single system in the market that is solving this problem at the administration level or at the public level. So, to solve these kinds of challenges, we are going to propose a system that will solve this problem at the administration level in hospitals and for normal humans at the public level. This research paper proposes to develop an IOT-based automatic bed vacancy detection system. That will help in solving the above-described problem. [3] During the pandemic of COVID-19, there was a lack of a system to verify the availability of beds equipped with the necessary infrastructure for the patients in question. This system is useful for normal days and in emergencies.

This is an innovation towards making the smart city more advanced by solving this problem from the root level.



II. BACKGROUND

[4] Hardware Techniques: The topic of interest pertains to the hardware components utilized in the Internet of Things (IoT) ecosystem. These are used in a variety of gadgets, including sensors, microcontrollers, bridges, etc. The primary engine that allows Internet of Things (IoT) technology to operate in real time is physical devices. This device's capabilities include monitoring, analyzing, communicating, controlling, and, while converting an analog signal to a digital one, sensing its surroundings. Local storage on the devices houses all the gathered data, which can then be transferred to external storage, such as databases or third-party systems, utilizing the internet connection built into the device's board, switches, and chips.

[3] Sensor: It is a physical tool for detecting surrounding objects. It can recognize certain types of input and react to them to produce an output. Data is gathered and converted into a form that is electric in nature. Data that can be read by

humans is displayed as the output of the sensor's measured values. To further comprehend the sensor, let's look at an example. The use of infrared sensors allows automatic doors to identify objects.

Infrared Sensor: Infrared radiation is the most common form of electromagnetic radiation that comes from the electromagnetic spectrum and has a longer wavelength than visible microwaves. Simply put, less electricity was needed. Since it can detect radiation with a wavelength range of 8 to 14 m, it can realistically detect the human body. PIR sensors, also known as pyroelectric sensors or passive infrared radiation sensors, are employed as motion detectors. The motion's velocity, direction, displacement, acceleration, and time can all be calculated. Even in movement, it is more precise and effective. As needed by the user, the output is transformed into digital form. There are active and passive types of infrared sensors. Active infrared sensors may both emit and detect infrared light. The two elements that make up an active IR sensor are a light-emitting diode (LED) and a receiver. When something is near the sensor, the LED's infrared light that reflects off of it is picked up by the receiver. Active IR sensors are often used in the obstacle detection systems of robots as proximity sensors. PIR sensors do not produce infrared radiation themselves; they only detect it when it is there. An infrared filter that blocks out all other light wavelengths, a Fresnel lens that concentrates light from various angles into a single point, and a housing unit that shields the sensor from other environmental factors like humidity are all parts of passive infrared sensors.

LCD Display: A liquid-crystal display is a flat-panel display or other electronically controlled optical device that uses polarizers and the light-modulating properties of liquid crystals. Liquid crystals don't generate light directly; instead, they use a backlight or reflector to produce coloured or monochromatic images. The results of the IoT sensor would then be loaded on the LCD for display, depicting the vacancy at the lower level rather than showing it on the website. Because LCDs have a parallel interface, operating an LCD requires the microcontroller to simultaneously manage many interface pins. Where data is written to the LCD's memory is determined by a register select (RS) pin on the interface. You can decide between using the instruction register, which is where the LCD controller looks for instructions on what to do next, or the data register, which stores the content of the screen. Additionally, you have a choice of the writing mode, the enable pin, and the eight data pins (D0-D7), as well as the read/write (R/W) pin. The states of these pins (high or low) correspond to the corresponding operations when bits are written to or read from registers, respectively. [4]

[4] Software Module: In the Internet of Things, the software module's task is to collect data from the hardware devices. They function as a communication platform between IoT devices and centralized databases with the help of a data server. The values are slotted and transferred to boost the physical device's memory storage capacity and processing power. Operating a software module built with predefined IoT devices and languages like C, C#, Java, etc. allows for some necessary processes to be enabled and more effective purposes to be achieved.

[4] Arduino Programming: The Arduino Integrated Development Environment processes code written on various Arduino board circuit chips using the hardware programming language known as Arduino. Arduino disassembled the microcontroller into a more usable form. A new word for the Arduino program is Sketch. The setup function is automatically called when a sketch is launched to initialize an Arduino board. For practical use, most microcontrollers are made with Arduino boards.

[4] Database Module: Database refers to the component that organizes and stores the collected data. A data record or file that contains all the information about the data is often found in a computer database. All created data is saved in a structured manner with trustworthy links between rows and columns. In database management, read-only and write access to a user's data is always very convenient. when it is in a structured form. The relational database's information is simple to retrieve, alter, and modify. Pre-defined categories are put up in relational databases. Each collection of data is kept as a table with at least one column corresponding to the
same category of rows. For application and user programs, it favors the Structured Query Language (SQL) interface.
Without any additional restrictions, they can be easily expanded for the inclusion of new data and the modification of existing data.

III. Literature Survey

According to some surveys, there is work going on with similar systems in different sectors.

[11] For lasers, Shan He, Shilun Feng, and others have presented "IoT-Based Laser-Inscribed Sensors for Detection of Sulphate in Water Bodies" in their research paper. This study served as the basis for the interaction between the

hospital's Wi-Fi and internet systems and the sensors. For the best situation, we have calculated the cost of laser-based sensors. The necessity of ports for connecting to the internet will be supported by this effort.

[10] The parameter(s) to be evaluated and checked when utilizing the laser-based sensor have been suggested by Gnath and colleagues in their paper titled "Designing and testing a laser-based vibratory sensor." This research also shed light on the applicability of these sensors. Our work on lasers' boundary conditions was influenced by these variables. These restrictions could be widened, and the bed tracking system could be strengthened in future studies.

One of the most important fields of research today is motion detection. In the presence of motion, many tasks are completed. The usage of the Arduino (UNO) microcontroller, ultrasonic sensor, passive infrared sensor, and many other devices to detect and measure distances has been one of the research's main areas of interest. The objective is to employ as little labour as possible while measuring and monitoring human behaviour remotely. The goal of this project was to create a sensor that can quickly determine how far an object is, track how those distances change as the object gets closer, and show the results on an LCD with a sound alert and a light-coded indicator.

[12] LIDAR has been discussed by Dekui LV, Xia Xin Yang, et al. in their paper titled "Research on the technology of LIDAR data processing." This document has been used in this work to better understand how LIDAR technology is employed in the medical industry. In this project, the sensor signal is controlled and sent to a web portal using an Arduino- based microcontroller.

Jinal Shah et al. (2018) utilized IoT in their paper titled "Smart Hospital Using IoT". In this paper, the authors extensively analyzed the usage and necessity of IoT technology to propose a system that combines sensor technology with the Internet of Things (IoT). They employed various sensors to measure different physiological details of a patient, such as heart rate, pressure, and temperature sensors. With this system, concerned authorities can remotely monitor a patient's health, the level of saline in the bottle, heartbeat, blood pressure, temperature, and control electricity from a distant location.

[5] The research aims to pioneer an innovative Android- based Remote Controlled hospital bed, integrating cutting- edge computer vision technology, and prioritizing energy efficiency. The bed is engineered to autonomously navigate along a designated track, proficiently surmounting obstacles aided by three ultrasonic sensors and two IR sensors for accurate obstacle detection and precise distance measurement.

TABLE. I. COMPARISON WITH OTHER PAPERS

Aspect	**IoT-Based Automatic Bed Vacancy Detection**	**Existing IoT-Based Systems in Medical Field**
Detection Method	Sensor	Various sensors (e.g., motion, pressure)
Purpose	Detect bed occupancy/vacancy in real-time	Monitor patient vital signs, activity, etc.
Application	Healthcare facilities	Hospitals, home healthcare, etc.
Primary Functionality	Bed occupancy monitoring	Patient monitoring and management(Manually)
Accuracy	High	Variable
Real-time Monitoring	Yes	Yes/No
Data Transmission	Wireless (e.g., Wi-Fi, Bluetooth)	Wireless and wired(e.g., Wi-Fi, Zigbee)
Cost	Moderate	High
Scalability	Scalable	Not Scalable
Installation and Maintenance	Complexity Low	Variable, depends on system complexity
Human Interference	No	Yes/No
Use Cases	Bed	Patient Monitoring

IV. METHODOLOGY

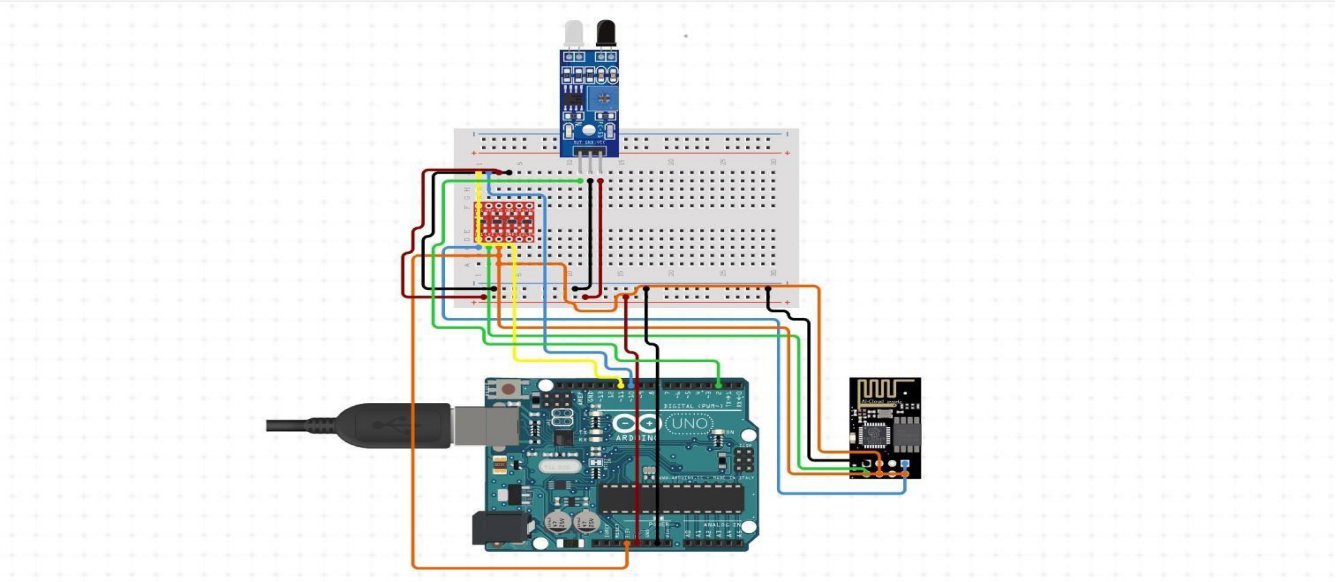


Fig. 2: Circuit diagram of the hardware model

It will come as a revolutionized system for the rural areas as they had to wait for a long time in search of bed but could find the bed. But this system will solve their problem in some way by locating a suitable location, a better hospital with an available bed. For this, we are going to use some kind of technology and tools, i.e., Arduino, IR sensors, LCD (to show the current counter of the filled status of beds out of the number of beds in a particular hospital), and a web interface (React is used to give the front end to the system).

1) IR sensors will identify the object using its property of object detection. An IR sensor can detect a person with its ability to detect IR radiation. It works with radar technology. The radiation comes towards the receiver end from the presence of the person, which will help in detecting the patient.

2) Then, after the object detection, there would be possible chances for the object to be detected or not. Here, that part also takes place, where the patient is out of bed for a certain threshold period, which would be counted as vacant after surpassing that time. To display the presence and altered frequency based on the patient's presence, we will also use an LCD for the prototype.

3) For the more enhanced user interface, there has been a significant attempt to provide this vacant status through the web interface. For enhanced systems, the Raspberry Pi will come into the picture, as will an IR sensor for detecting the presence of a person (the IR sensor will detect it through transmitted infrared (IR) rays and receiving the presence by the receiver end). The Raspberry Pi is usually used where a lot of complex operations are required. It can also communicate with several Arduinos since the Raspberry Pi works as a full-fledged microprocessor.

4) For transferring data from the sensor to the server, we are going to use a Bluetooth module, which will transfer the signals from the sensor to the server. Here, in the database, all the important information will be stored.

5) After receiving the data from the Wi-Fi module in JSON, webpage data will be changed dynamically with the help of the document object model. If a person is discharged from the hospital, then the bed is again available for people, and the status becomes ‘Available’ in green colour. If the patient occupies the bed, then that bed's status will be changed to ‘Not Available’ in red colour.

6) We will generate a list of additional hospitals where he can find beds if he wants to reserve a bed, but it is not available, meaning it is occupied by another patient. If all the hospitals are full, then the process of booking beds will end. If the bed is available again, then we send the information that the bed you are looking for is available so that he can perform that process again and get a confirmed bed. We will store the user data so that, with the help of nature-based prediction algorithms, we can predict the future traffic about bed booking and inform the hospital management so that they can prepare themselves.

V. Result Analysis:

In our research, the role of Arduino is pivotal in enabling the seamless detection of object presence within the bed occupancy detection system. This microcontroller facilitates the integration of various sensors, particularly the IR sensor, allowing for efficient detection of occupancy status without the need for human intervention. Additionally, our system boasts a user-friendly web interface that displays real-time bed availability status, a feature absent in previous manual systems. By automating this process, we achieve a remarkable accuracy rate of over 90%, ensuring transparency in bed management operations.

Furthermore, our proposed system significantly reduces costs by 50-60% compared to traditional manual systems that rely on human intervention for bed status updates. This cost-saving advantage underscores the practicality and economic feasibility of our IoT-based solution in healthcare settings.

A distinctive feature of our system lies in its ability to automatically update bed availability data using WebRTC (Web Real-Time Communication) sockets. By leveraging this technology, the need for manual intervention is eliminated. If a predefined threshold time is exceeded, signalling potential bed vacancy or occupancy, the Arduino initiates the necessary updates, seamlessly reflecting the status change in the web interface. This automated process enhances the efficiency and reliability of our system, setting it apart from other existing solutions in terms of effectiveness and ease of use.

VI. Conclusion

The implementation of an IoT-based automatic bed vacancy detection system in hospitals promises to significantly enhance healthcare management. This project introduces a systematic facility management approach aimed at expediting bed and service bookings within hospital premises. Leveraging IR and ultrasonic sensors, in conjunction with a server and Raspberry Pi, this system operates at a comprehensive level. The IR sensors diligently monitor bed occupancy status, ensuring timely updates. Utilizing IoT modems, Raspberry Pi establishes connectivity with the server, which hosts an integrated database for data storage and facilitates device communication via a web application.

This innovative solution stands to revolutionize healthcare accessibility for the general populace. By enabling pre- booking of patient beds and necessary facilities through a user-friendly web application, both ambulance drivers and ordinary citizens gain the convenience of securing accommodations and treatment solutions before hospital arrival. Such proactive measures hold the potential to mitigate mortality rates stemming from bed scarcity and inadequate treatment provision. In essence, the proposed system heralds a paradigm shift towards proactive healthcare management, ultimately fostering improved patient outcomes and healthcare service delivery.

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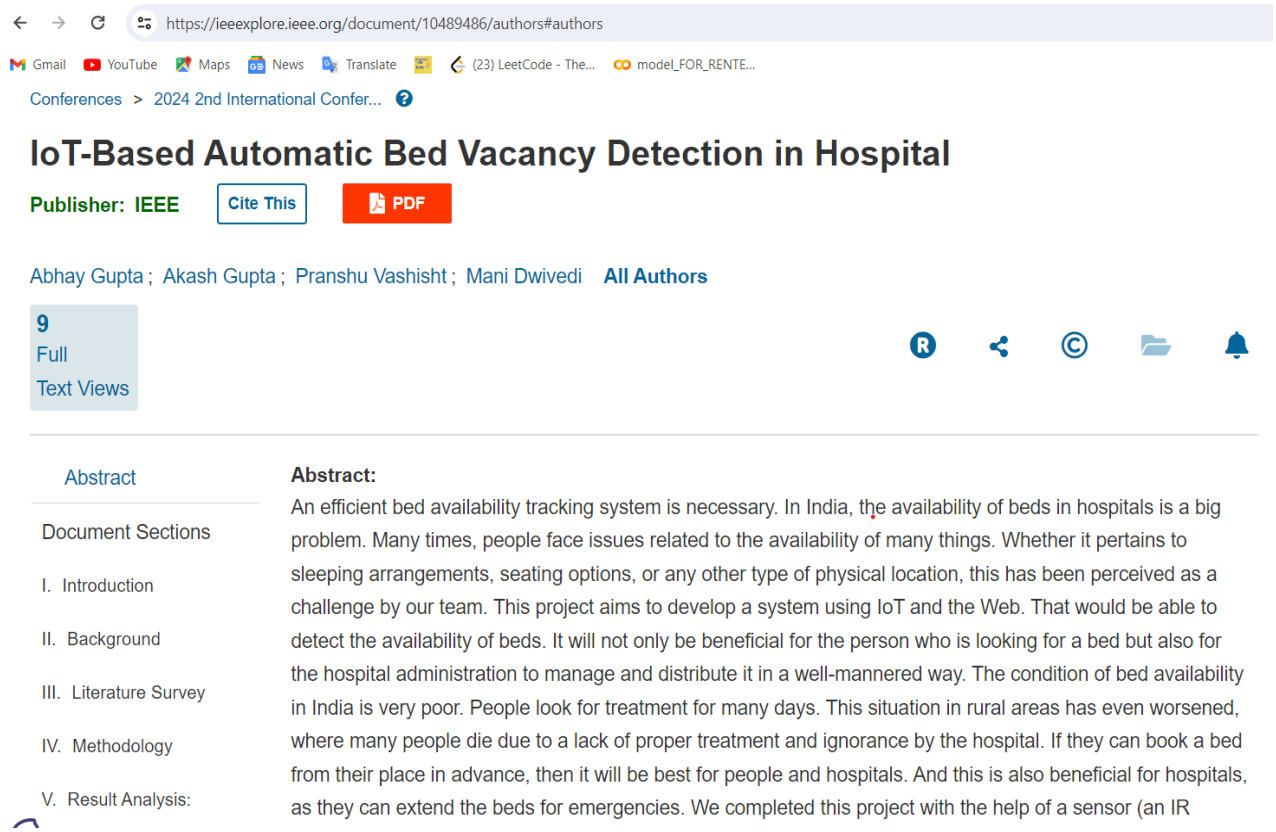

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